Question 1

This question contains multiple parts. Make sure to read all the instructions and answer each part.

A train moves on a straight track of length d=4.86 km connecting two stations. When speeding up the engine can deliver an acceleration of $a_1 = 0.972 \frac{m}{s^2}$. When breaking the brakes can deliver an acceleration of magnitude $a_2 = 0.298 \frac{m}{s^2}$

Part a

(1 points)

The train leaves the first station from rest and the engine constantly accelerates, what is the velocity with which the train reaches the second station ?

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

97.2 m/s Your Answer

Part b

(1 points)

What is the total time it takes for the train to start at the first station, accelerate for some time, then immediately break for some time and come to a stop at the second station ?

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

206 s Your Answer

Your actual answer was 206.44 which differs from the answer above by a small rounding error or significant figures. Check with your instructor how this will be graded in a testing situation.

Question 2

This question contains multiple parts. Make sure to read all the instructions and answer each part.

You look outside of your window in you apartment on the 5th floor. You see a ball going straight up and measure the time it takes for the ball to cross the window from the bottom to the top $t=0.463$ s. The distance between the bottom and the top of the window is $h=1.29$ m.

Part a

(1 points)

What is the velocity of the ball when it passes the bottom of the window ?

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

5.05 m/s Your Answer

Part b

(1 points)

After some time you observe that the ball is coming straight down outside the window, what is the time it takes for the ball to pass from the top to the bottom of the window ?

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

0.463 s Your Answer

Part c

(1 points)

Calculate the maximal height the ball will reach, measured from the bottom of the window.

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

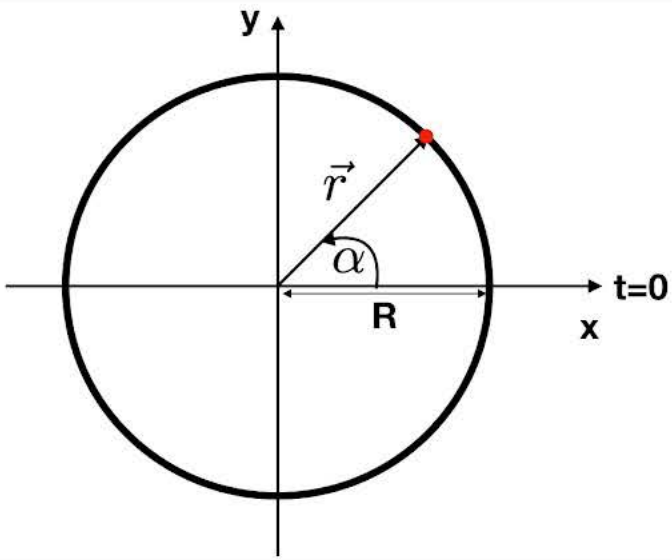
1.3 m Your Answer

Question 3

This question contains multiple parts. Make sure to read all the instructions and answer each part.

A small objects moves on a circle of radius R=7.90 m. The speed of the object as a function of time is $v = c_1 t$ with c_1 =2.98 $\frac{m}{s^2}$

Image size: s M L Max



Part a

(1 points)

The object starts at t=0 on the positive x-axis and moves counterclockwise around the circle. When the object has an angle α = 30.1 degrees with respect to the positive x-axis ,measured counterclockwise, what is the direction of the instantaneous velocity vector (with respect to the positive x-axis, measured counterclockwise) ?

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

120 degrees ✓ Your Answer

Your actual answer was 120.1 which differs from the answer above by a small rounding error or significant figures. Check with your instructor how this will be graded in a testing situation.

Part b

(1 points)

What is the magnitude of the instantaneous acceleration vector at time t= 1.32 s ?

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

3.57 m/s^2 ✓ Your Answer

Question 4

This question contains multiple parts. Make sure to read all the instructions and answer each part.

The position of an object in three dimensions as a function of time is given by

$$\vec{r} = (at^2 + bt)\hat{i} + ct^2\hat{j} + d\hat{k}$$

Where $\hat{i}, \hat{j}, \hat{k}$ are the unit vectors in the x,y and z direction, respectively.

The parameters take the following values:

a=3.15 $\frac{m}{s^2}$

b=-3.70 $\frac{m}{s}$

c=5.86 $\frac{m}{s^2}$

d=-1.76 m

Part a

(1 points)

What is the speed of the object at times t= 1.81 s ?

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

22.6 m/s ✓ Your Answer

Your actual answer was 22.56 which differs from the answer above by a small rounding error or significant figures. Check with your instructor how this will be graded in a testing situation.

Part b

(1 points)

Find the time when the instantaneous acceleration $\vec{a}$ and the instantaneous velocity $\vec{v}$ vectors are orthogonal.

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

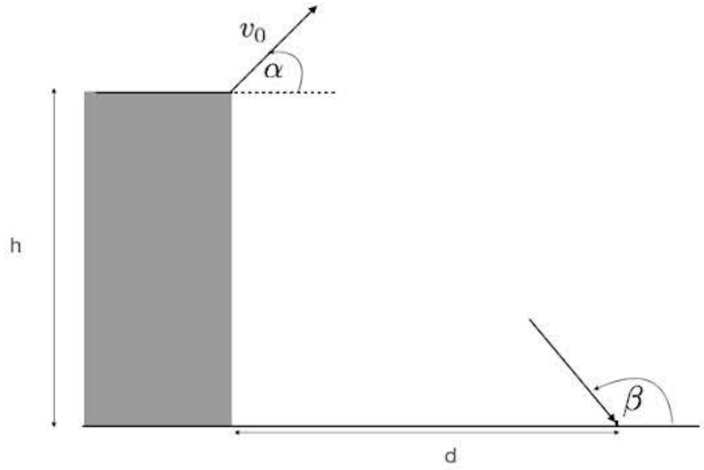
0.132 s ✓ Your Answer

Question 5

This question contains multiple parts. Make sure to read all the instructions and answer each part.

You throw a ball off a cliff of height h=13.3 m, the initial speed is $v_0 =$ 14.7 $\frac{m}{s}$ and the angle with respect to the horizontal (measured counter clockwise) is given by $\alpha =$ 32.5 degrees. The object lands a distance d on the ground below the cliff. (Note the figure is not drawn to scale)

Image size: s M L Max



Part a

(1 points)

What is the maximum height above the ground the ball reaches ?

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

16.5m Your Answer

Part b

(1 points)

What is the angle β the ball makes with respect to the horizontal (measured counter clockwise) when it lands on the ground ? Please give the answer in degrees

Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

125degrees Your Answer

Your actual answer was 124.6 which differs from the answer above by a small rounding error or significant figures. Check with your instructor how this will be graded in a testing situation.

Question 6

(1 points)

For the first five seconds after take-off the rocket engine can deliver a net acceleration (i.e. we include the contribution of gravity into this acceleration) of magnitude

$$a = c\,t^2 + b$$

with

c= 7.04 $\frac{m}{s^4}$

b=10.4 $\frac{m}{s^2}$

What is the speed of the rocket 3.94 seconds after take off ?

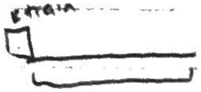
Please enter a numerical answer below. Accepted formats are numbers or "e" based scientific notation e.g. 0.23, -2, 1e6, 5.23e-8

185 m/s ✓ Your Answer

Physics 1A Midterm 1

I acknowledge the above-mentioned terms of the UCLA student code of conduct, declare that my work will be solely my own, and that I will not communicate with anyone other than the instructer + proctors in any way during the exam

signed: Marisa Duran

1. 

$d = 4.86\,km = 4860\,m$

$a_1 = .972\ m/s^2$ (speeding up)

$a_2 = .298\ m/s^2$ (slowing down)

a) constant acceleration: using equation $x(t) = x_0 + V_0 t + \frac{1}{2}at^2$

In this case, $x(t) = d = 4860\,m$, $x_0 = 0\,m$, $V_0 = 0\,m/s$ (assuming the train starts from rest)

$a = a_1 = .972\ m/s^2$ because the train is speeding up.

$$d = 0 + 0t + \frac{1}{2}a_1 t^2$$

$$d = \frac{1}{2}a_1 t^2 \rightarrow 4860\,m = \frac{1}{2}(.972\,m/s^2)\,t^2$$

$$t = \sqrt{\frac{4860\,m}{\frac{1}{2}(.972\,m/s^2)}}$$

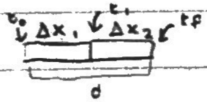
$$t = 100\ s$$

From t, we can find the final velocity V_F

gen. equation: $v(t) = V_0 + at \rightarrow V_f = V(t) = V_0 + a_1 t$

$$V_f = V(100) = 0 + (.972\,m/s^2)(100\,s)$$

$$V_F = 97.2\ m/s$$

b) 

during length Δx_1: $\Delta t = t_1 - t_0$ $(t_0 = 0)$ so $\Delta t = t_1$

$a = a_1 = .972\,m/s^2$ $\quad V_0 = 0\,m/s$ $\quad X_0 = 0\,m$

$\Delta x_1 = x_1 - x_0$ so $\Delta x_1 = x_1$ $\quad V(t_1) = ?$

during length Δx_2: $\Delta t = t_f - t_1$

$a = a_2 = -.298\,m/s^2$ $\quad V_0 = V(t_1)$ $\quad x_0 = x_1$

$\Delta x = x_f - x_1$ $\quad x_f = d = 4860\,m$ $\quad V_f = v(t_f) = 0$

general equation: $v(t) = v_0 + at \rightarrow v(t_1) = 0 + a_1 t_1 \rightarrow$ solve for t_1: $t_1 = \frac{v(t_1)}{a_1}$

for length Δx_1: $x(t) = x_0 + v_0 t + \frac{1}{2}at^2 \rightarrow x_1 = 0 + 0 + \frac{1}{2}a_1 t_1^2 \rightarrow$ plug in t_1: $x_1 = \frac{1}{2}a_1\left(\frac{v(t_1)^2}{a_1^2}\right) = \frac{v(t_1)^2}{2a_1}$

for length Δx_2: $v(t) = v_0 + at \rightarrow v(t_f) = V(t_1) + a_2 t_f \rightarrow 0 = v(t_1) + a_2 t_f$

from above, $v(t_1) = a_1 t_1$ so $0 = a_1 t_1 + a_2 t_F \rightarrow t_f = \frac{-a_1 t_1}{a_2}$

$x(t) = x_0 + v_0 t + \frac{1}{2}at^2 \rightarrow d = x_1 + v(t_1)t_f + \frac{1}{2}a_2 t_f^2$

substituting: $x_1 = \frac{v(t_1)^2}{2a_1}$, $t_f = \frac{-a_1 t_1}{a_2} \rightarrow d = \frac{v(t_1)^2}{2a_1} + v(t_1)\left(\frac{-a_1 t_1}{a_2}\right) + \frac{1}{2}a_2\left(\frac{a_1^2 t_1^2}{a_2^2}\right)$

$$d = \frac{v(t_1)^2}{2a_1} + v(t_1)\left(-\frac{a_1 t_1}{a_2}\right) + \frac{a_1^2 t_1^2}{2a_2}$$

substituting $t_1 = \frac{v(t_1)}{a_1} \rightarrow d = \frac{v(t_1)^2}{2a_1} + v(t_1)\left(\frac{-a_1 v(t_1)}{a_1 a_2}\right) + \frac{a_1^2 v(t_1)^2}{2a_2 a_1^2}$

1b cont) Simplifying $d = \frac{v(t_1)^2}{2a_1} + v(t_1)\left(\frac{-a_1 v(t_1)}{a_1 a_2}\right) + \frac{a_1^2 v(t_1)^2}{2a_2 a_1^2}$

$$d = \frac{v(t_1)^2}{2a_1} - \frac{v(t_1)^2}{a_2} + \frac{v(t_1)^2}{2a_2}$$

$$d = \frac{a_2 v(t_1)^2}{2a_1 a_2} - \frac{2a_1 v(t_1)^2}{2a_1 a_2} + \frac{a_1 v(t_1)^2}{2a_1 a_2} = \frac{a_2 v(t_1)^2 - a_1 v(t_1)^2}{2a_1 a_2}$$

substituting values:

$$4860\,m = \frac{(-.298\,m/s^2 - .972\,m/s^2)\,v(t_1)^2}{2(.972\,m/s^2)(-.298\,m/s^2)}$$

$m = s^2/m$

$$4860\,m = \frac{-1.27\,m/s^2\,v(t_1)^2}{-.579\,m^2/s^4}$$

$$2216.89\,m^2/s^2 = v(t_1)^2$$

$$v(t_1) = 47.08\,m/s$$

finding t_1: from earlier, $t_1 = \frac{v(t_1)}{a_1} = \frac{47.08\,m/s}{.972\,m/s^2} = 48.44\,s$

finding t_f: from before, $t_f = \frac{-a_1 t_1}{a_2} = \frac{-.972\,m/s^2 \cdot 48.44\,s}{-.298\,m/s^2} = 158.00\,s$

$t_{total} = 48.44\,s + 158\,s = 206.44\,s$

2. window — $h = 1.29\,m$, $\leftarrow t_1 = .463\,s$, $t_0 = 0$

a) Find v at time t_0 (so find v_0) $\quad \Delta y = 1.29\,m = x(t_1) - x_0 \quad a = -g = -9.80\,m/s^2$

$t_1 = .463\,s$

general equation: $y(t) = y_0 + v_0 t + \frac{1}{2} a t^2$

substituting: $\Delta y = v_0 t_1 - \frac{1}{2} g t_1^2$

$$1.29\,m = v_0 (.463\,s) - \frac{1}{2} g (.463\,s)^2$$

$$v_0 = \frac{1.29\,m - \frac{1}{2} g (.463\,s^2)}{.463\,s} = 5.05\,m/s$$

b) the trajectory is symmetrical. the ball will fall past the window on the way down in the same amount of time it took to go up the window.

$t = .463\,s$

c) find the max height:

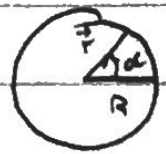
when the ball is at the max height, $V = 0\,m/s$. let t_{max} be the time where the ball is at its max height

gen eqn: $v(t) = v_0 + at \rightarrow 0 = v_0 - g t_{max} \quad \frac{-v_0}{-g} = t_{max} \quad t_{max} = \frac{5.05\,m/s}{g} = .515\,s$

gen eqn: $y(t) = y_0 + v_0 t + \frac{1}{2} a t^2 \rightarrow y(t_{max}) = 0 + v_0 t_{max} - \frac{1}{2} g t_{max}^2$

substituting numbers: $\quad y(t_{max}) = 5.05\,m/s\,(.515\,s) - \frac{1}{2} g (.515\,s)^2$

$y(t_{max}) = 1.30\,m$

3. 

$v = c_1 t$ $\quad c_1 = 2{,}98\ m/s^2$ $\quad R = 7.90\ m$

a) $\alpha = 30{,}1°$

$\vec v$ should be perpendicular to $\vec r$

← +x axis

$\beta = 180 - 90 - \alpha = 59.9°$

$\gamma = 360 - 90 - 90 - \beta = 120.1°$

b) at time $t = 1.32s$, find $|\vec a|$

$\vec a$ is composed of a_{rad} and a_{tan}

From book: $a_{rad} = \frac{v^2}{R}$ $\quad a_{tan} = \frac{d|\vec v|}{dt} = \frac{dv}{dt}$

$$a_{rad} = \frac{(c_1 t)^2}{R} = \frac{c_1^2 t^2}{R}$$

$$a_{rad} = \frac{(2{,}98 m/s^2)^2 \cdot (1.32s)^2}{7{,}90\ m} = 1.96\ m/s^2$$

$$a_{tan} = \frac{dv}{dt} = c_1 = 2{,}98\ m/s^2$$

$$|\vec a| = \sqrt{1{,}96^2 + 2{,}98^2} = 3.57\ m/s^2$$

4. $\vec{r} = (at^2 + bt)\hat{i} + ct^2\hat{j} + d\hat{k}$ where $a = 3.15\,m/s^2$ $b = -3.70\,m/s^2$ $c = 5.86\,m/s^2$ $d = -1.76\,m/s^2$

a) find speed at $t = 1.81\,s$

$\vec{v} = \frac{d}{dt}\vec{r}$ (velocity is the derivative of position).

$\vec{v} = (2at + b)\hat{i} + 2ct\hat{j} + 0\hat{k}$

at $t = 1.81$, $\vec{v} = (2(3.15\,m/s^2)(1.81\,s) - 3.7\,m/s^2)\hat{i} + 2(5.86\,m/s^2)(1.81\,s)\hat{j}$

$\vec{v} = (7.7\,m/s)\hat{i} + (21.21\,m/s)\hat{j}$

speed $= |\vec{v}| = \sqrt{(7.7\,m/s)^2 + (21.21\,m/s)^2 + 0} = 22.56\,m/s$

b) Find a time when $\vec{a} \perp \vec{v}$

acceleration is the derivative of velocity so $\vec{a} = \frac{d}{dt}\vec{v} = 2a\hat{i} + 2c\hat{j} + 0\hat{k}$

the vectors are orthogonal when $\vec{a} \cdot \vec{v} = 0$

$(2a\hat{i} + 2c\hat{j}) \cdot (2at + b\hat{i} + 2ct\hat{j}) = 0$

$4a^2t + 2ab + 4c^2t = 0$

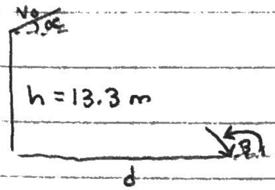
$4(3.15\,m/s^2)^2 t + 2(3.15\,m/s^2)(-3.7\,m/s^2) + 4(5.86\,m/s^2)^2 t = 0$ 5

$39.69\,m^2/s^4\,t - 23.31\,m^2/s^4 + 137.36\,m^2/s^4\,t = 0$

$177.05\,m^2/s^4\,t = 23.31\,m^2/s^4$

$t = .132\,s$

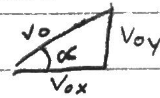
5.



$V_o = 14.7\ m/s$ $\alpha = 32.5°$

a) Find max height. $a_y = -g = -9.80\ m/s^2$

finding x, y components of v_o.



$V_{oy} = V_o \sin\alpha = 14.7 m/s \sin 32.5°$

$V_{oy} = 7.90\ m/s$

$V_{ox} = V_o \cos\alpha = 14.7 m/s \cos 32.5°$

$V_{ox} = 12.40\ m/s$

at max height, $V_y = 0\ m/s$, $t = t_{max}$

gen eqn: $V_y(t) = V_{oy} + a_y t$

$\downarrow$

$V_y(t_{max}) = V_{oy} - g\, t_{max}$

$0 = V_{oy} - g\, t_{max}$ $t_{max} = \frac{V_{oy}}{g} = \frac{7.90 m/s}{g} = .806 s$

gen eqn: $y(t) = y_o + V_{oy} t + \frac{1}{2} a_y t^2$

$\downarrow$ $y(t_{max}) = h + V_{oy} t_{max} - \frac{1}{2} g\, t_{max}^2$

$y(t_{max}) = 13.3 m + 7.9 m/s (.806 s) - \frac{1}{2} g (.806 s)^2$

$y(t_{max}) = 16.5\ m$

b) find the direction of the final velocity vector to find β

gen eqn: $y(t) = y_o + V_{oy} t + \frac{1}{2} a_y t^2$

let y_o = max height = 16.5m and $y(t_f) = 0\ m$, and $V_{oy} = 0\ m/s$

$-16.5 m = 0 t_f - \frac{1}{2} g\, t_f^2$

$-16.5 m = -\frac{1}{2} g\, t_f^2$ $t_f = \sqrt{\frac{2 \cdot 16.5 m}{g}} = 1.83\ s$

$t_{total} = t_{max} + t_f = .806 s + 1.83 s = 2.64 s$

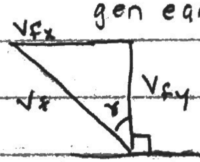
gen eqn: $V_y(t) = V_{oy} + a_y t$ let $V_{oy} = 7.90\ m/s$ again

$\downarrow$

$V_y(t_{total}) = V_{oy} - g\, t_{total}$

$V_y(t_{total}) = 7.9 m/s - g(2.64 s) = -17.97\ m/s = V_{fy}$

gen eqn: $V_x(t) = V_{ox} + a_x t$ $a_x = 0\ m/s^2$



$V_x(t_{total}) = V_{ox} + 0 = 12.4\ m/s = V_{fx}$

$\tan\gamma = \frac{V_{fx}}{V_{fy}}$ $\gamma = \tan^{-1}\left(\frac{12.4 m/s}{17.97 m/s}\right) = 34.6°$

$\beta = \gamma + 90° = 34.6° + 90° = 124.6°$

6. $a = ct^2 + b$ (net acceleration)

$c = 7.04\ m/s^4$ $b = 10.4\ m/s^2$

speed at 3.94 s $= \int_0^{3.94s} a\,dt = \int_0^{3.94s} ct^2 + b\,dt = \left[\frac{ct^3}{3} + bt\right]_0^{3.94s}$

$= \frac{1}{3} \cdot 7.04\,m/s^4 \cdot (3.94s)^3 + 10.4\,m/s^2 \cdot 3.94s$

$= 184.5\ m/s$